

Olympic Games during nationwide lockdown: sports injuries and illnesses, including COVID-19, at the Beijing 2022 Winter Olympics

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► Additional supplemental material is published online only. To view, please visit the journal online (<http://dx.doi.org/10.1136/bjsports-2023-107412>).

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Accepted 10 October 2023

ABSTRACT

Objective The objective of this study is to describe the incidence of injuries and illnesses sustained during the Beijing Winter Olympic Games from 4 February 2022 to 20 February 2022.

Methods We recorded the daily number of athlete injuries and illnesses (1) through the reporting of all National Olympic Committee (NOC) medical teams and (2) in the polyclinic and medical venues by the Beijing 2022 medical staff.

Results In total, 2848 athletes (1276 women, 45%; 1572 men, 55%) from 91 NOCs were followed prospectively for the occurrence of injury and illness. NOC and Beijing 2022 medical staff reported 289 injuries and 109 illnesses, equalling 10.1 injuries and 3.8 illnesses per 100 athletes over the 17-day period. The injury incidence was highest in ski halfpipe (30%), ski big air (28%), snowboard slopestyle (23%) and ski slopestyle (22%), and lowest (1%–2%) in curling, alpine mixed team parallel slalom, Nordic combined and alpine super-G. The illness incidence was highest in ski aerials (10%), skeleton (8%), cross-country skiing (8%) and Nordic combined (7%). In the study period, COVID-19 affected 32 athletes, accounting for 29% of all illnesses affecting 1.1% of all athletes.

Conclusion Overall, 10% of the athletes incurred an injury and 4% an illness during the Beijing Winter Olympic Games. The incidence of illnesses overall, which was the lowest yet recorded in the Winter Olympic Games, and COVID-19 was mitigated through comprehensive countermeasures.

INTRODUCTION

Competing in the Olympic Games is the ultimate goal for many athletes and often the pinnacle of an athlete's career. The physical and mental stress of training and international competition exposes athletes to a heightened risk of both injury and illness.^{1,2} When athletic performances are measured to the hundredth of a second, even minor injuries and illnesses can have a significant impact on the outcome. Therefore, the prevention of injuries and illnesses at this critical moment in the life of an athlete is of the utmost importance.

In 2008, the International Olympic Committee commissioned the first major injury surveillance system for the Beijing Summer Olympics.^{3,4} Fourteen years later, as the Olympics returned to Beijing

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Data on injuries and illnesses to inform medical preparations and preventive measures at winter sporting events are limited.

WHAT THIS STUDY ADDS

⇒ Overall, 10% of athletes incurred at least one injury and 4% at least one illness during the Beijing 2022 Olympic Games.
⇒ Ski halfpipe (30%), ski big air (28%), snowboard slopestyle (23%), and ski slopestyle (22%) were the sports with the highest incidences of injury.
⇒ The athletes and the Games' organisers faced significant challenges due to the COVID-19 pandemic, at a time when the host nation was in strict lockdown, but spread of infection was mitigated through comprehensive countermeasures.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Athlete medical staff and event organisers for winter sports can plan and optimise their healthcare provisions and preventive measures based on the injury and illness profile of their athlete cohorts.
⇒ The effectiveness of the COVID-19 countermeasures; such as mask wearing, handwashing, physical distancing and avoiding indoor congregation; in mitigating not only COVID-19 but also other respiratory infections provide an opportunity for both National Olympic Committees (and all other sport teams) and event organisers to consider which measures could reasonably be carried forward to optimise athlete health.

for the XXIV Olympic Winter Games, injury and illness surveillance continues as an integral part of the International Olympic Committee's (IOC) initiatives to protect the health of the athletes.⁵

The Beijing Games were held only 6 months after the Tokyo Summer Olympics, which had been postponed by 1 year due to the outbreak of the global COVID-19 pandemic. With the pandemic still in full effect, the organisation of the Beijing Games was further complicated by China's nationwide



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To cite: Soligard T, Palmer D, Steffen K, et al. *Br J Sports Med* Epub ahead of print: [please include Day Month Year]. doi:10.1136/bjsports-2023-107412

zero-COVID-19 policy, as well as by the substantial surge in new COVID-19 cases worldwide (outside of China) following the new Omicron variant of SARS-CoV-2 emerging in November 2021. A number of countermeasures were implemented, including a 'closed-loop' management system to separate both international participants and local workforce inside the loop from the general population on the outside.⁶

The purposes of this study were to measure and characterise injuries and illnesses experienced by athletes, across all sports, participating in the Beijing 2022 Winter Olympics.

METHODS

We followed the recommendations of the IOC consensus statement on methods for recording and reporting of epidemiological data on injury and illness in sports in this prospective cohort study.⁷ We invited all National Olympic Committee (NOC) medical teams to report the daily occurrence (or non-occurrence) of athlete injuries and illnesses using either an electronic report form (through Microsoft Forms), a fillable PDF or a paper form. Concurrently, we retrieved the same injury and illness information on all athletes treated in the polyclinic and all other medical venues operated by the Beijing Organising Committee of the Olympic and Paralympic Games (Beijing 2022/OCOG) medical staff. These data were collected through the OCOG electronic medical record system.

Implementation

The day before the opening of the Games we organised a meeting for all NOC medical staff. At this meeting we informed them about the protocol and reporting methods, answered questions, and, to those who wanted, distributed paper report forms.

Throughout the data collection, we actively followed up with the NOCs with 10 or more participating athletes with frequent visits (respecting COVID-19 countermeasures) and electronic contact to address any questions and encourage continuous reporting during the Games. We recorded the response rate (and injuries and illnesses) of all the participating NOCs.

Definition of injury and illness

We defined injuries as tissue damage or other derangement of normal physical function due to participation in sports, resulting from rapid or repetitive transfer of kinetic energy, and illnesses as complaints or disorders not related to injury.⁷ We recorded all injuries and illnesses that were new (ie, excluding pre-existing or not fully rehabilitated conditions) or recurring (athletes having fully recovered after a previous condition) incurred in competition or training during the period between the Opening and Closing Ceremonies of the Beijing Olympics 2022 (4 February 2022–20 February 2022) receiving medical attention, regardless of the consequences with respect to absence from competition or training. In cases where a single incident caused multiple injury types, we recorded only the most severe diagnosis, as determined by our research team based on all available clinical data.⁷ In the interest of presenting complete data on COVID-19 in athletes at the Games, we also report all confirmed cases occurring before the opening of the Games (from the day the athletes arrived at the airport in Beijing), but do not include these in the analyses overall and per sport (to avoid skewing the results in comparison to past and future Games).

Injury and illness report form

The variables and taxonomy of our injury and illness report form followed the recommendations of the IOC consensus statement.⁷

With respect to injuries, we recorded the following data: accreditation number, sport and event, date of injury, whether the injury occurred in competition or training (or other), whether it was new or recurrent, mode of onset, mechanism, body region, type and duration of time loss (estimated at time of reporting). We recorded data on illnesses in a similar fashion: accreditation number, sport and event, date of onset, organ system, aetiology and estimated duration of time loss. In addition to the aforementioned variables, we queried the Games athlete database for the age and sex of the injured or ill athlete.

We provided instructions and examples on how to complete the form correctly. Furthermore, the report form was available in eight languages: English, French, Chinese, German, Japanese, Korean, Russian and Spanish.

Confidentiality

We treated all information confidentially, and deidentified our database after the Games, ensuring anonymity of all athletes.

Patient and public involvement

Patients were not involved in the planning or execution of the study. Representatives of the patients (the athletes) will be invited to help interpret the results and their relevance and potential for future injury and illness prevention measures.

Equity, diversity and inclusion statement

Our study population includes all athletes participating in the Olympic Games. Our author group includes mixed genders (five women, seven men), continents (Asia, Europe, North and South America), nationalities (Brasil, China, Germany, Ireland, Norway, Russia, Switzerland, United Kingdom, United States of America), ages and professional backgrounds, as well as representation from two former Olympians (DP and RB).

Data analysis

In cases where athletes were treated for the same condition by both the NOC and Beijing 2022 medical staff, we retained the most complete data source (duplicates were removed). We calculated the summary measures of injury and illness incidences (i) according to the formula $i=n/e$, where n is the number of injuries or illnesses in competition, training or in total during the study period and e is the respective number of exposed (participating) athletes; with incidence proportions presented as injuries/illnesses per 100 athletes.⁷ We also calculated the summary measures of injury and illnesses per 1000 athlete-days, where athlete-days correspond to the total number of athletes multiplied by 17 days. We calculated confidence intervals of the risk ratio (RR) of the number of injuries or illnesses between two groups by a simple Poisson model, assuming constant hazard per group and adjusting for sport, sex, age and/or NOC size (by the number of athletes) where appropriate. We present injury and illness incidences as means and RRs with 95% CIs. We regarded two-tailed p values <0.05 as significant.

RESULTS

In total, 2848 athletes took part in the Beijing Olympic Games. Of these, 1276 were women (45%) and 1572 men (55%).

Throughout the 17 days of the Games, the 91 NOCs submitted 1213 of maximal 1547 daily reports (78%; 13 countries did not submit any data) (table 1). The response rate of the 36 NOCs with ≥ 10 participating athletes (accounting for 95% of all the athletes) was 96% (585 of 612 reports).

Table 1 Response rates, injuries and illnesses in NOCs of different sizes (measured by number of athletes)

	<10 athletes	10–49	50–99	>99	All athletes
No of NOCs (athletes)	55 (154)	17 (437)	8 (547)	11 (1710)	91 (2848)
Injuries (injuries per 100 athletes)	18 (11.7)	50 (11.4)	59 (10.8)	162 (9.5)	289 (10.1)
Illnesses (illnesses per 100 athletes)	3 (1.9)	32 (7.3)	13 (2.4)	61 (3.6)	109 (3.8)
Daily reports submitted (%)	628 (67)	265 (92)	135 (99)	185 (99)	1213 (78)
Recorded by both NOC and OCOG					
Injuries (%)	4 (22)	8 (16)	12 (20)	32 (20)	56 (19)
Illnesses (%)	0 (0)	1 (3)	0 (0)	1 (2)	2 (2)
Recorded only by NOCs					
Injuries (%)	6 (33)	32 (64)	35 (59)	94 (58)	167 (58)
Illnesses (%)	0 (0)	13 (41)	10 (77)	33 (54)	56 (51)
Recorded only by OCOG					
Injuries (%)	8 (44)	10 (20)	12 (20)	36 (22)	66 (23)
Illnesses (%)	3 (100)	18 (56)	3 (23)	27 (44)	51 (47)

NOC, National Olympic Committee; OCOG, Organising Committee of the Olympic and Paralympic Games.

Injury and illness records by data source

Only 19% of all injuries and 2% of all illnesses were captured by both the NOCs and the Beijing 2022 staff. While 58% of the injuries and 51% of the illnesses were recorded solely by the NOCs, 23% and 47% of the injuries and illnesses, respectively, were recorded solely by the Beijing 2022 staff (table 1).

Injuries overall, by sport and sex

We recorded a total of 289 injuries, equalling 10.1 injuries (95% CI 9.0 to 11.3) per 100 participating athletes. This corresponds to 6.0 injuries per 1000 athlete-days. Overall, 10% (n=271) of all athletes sustained at least one injury. Of these, 14 athletes sustained 2 injuries, and 2 athletes sustained 3 injuries.

Figure 1 shows the incidence proportion of injured athletes in each sport (additional details are available in online supplemental appendix 1). The incidence of injury was highest in ski halfpipe (30.2 injuries (95% CI 13.8 to 46.7) per 100 athletes), ski big air (28.1 (95% CI 14.3 to 41.8)), snowboard slopestyle (23.3 (95% CI 11.1 to 35.6)) and ski slopestyle (22.4 (95% CI 10.2 to 34.6)) and lowest in curling, alpine mixed team parallel slalom, Nordic combined and alpine super-G (ranging from 0.9 to 2.2 injuries per 100 athletes).

When adjusting for sport, age and NOC size, there was no difference in overall injury incidence between women (10.0 injuries (95% CI 8.3 to 11.8) per 100 athletes) and men (8.7 (95% CI 7.2 to 10.1), adjusted RR 1.18 (95% CI 0.91 to 1.52), information on sex missing for 25 injuries (online supplemental appendix 1).

Severity of injuries

While 51% of the injuries were estimated to result in no time loss from sport (n=146), 35% (n=100) were expected to entail ≥ 1 day of time loss from competition or training (data missing for 43 injuries; online supplemental appendix 1). It was estimated

that 18% of the injuries (n=53) would result in an absence from sports from 1 to 7 days, 6% (n=17) in an absence from 8 to 28 days and 10% (n=30) in an absence for more than 28 days. Figure 1 shows the incidence of injuries estimated to lead to ≥ 1 day and >7 days of absence in each sport. Box 1 presents the details of the 47 injuries with >7 days of time loss.

Location and type of injuries

The most commonly injured body parts were the knee (n=38), head (n=35), shoulder (n=32), lumbosacral spine/buttock (n=30) and hand (n=23). The most common injury types were joint sprain/ligament tear (n=62), muscle strain/rupture/tear (n=33), superficial contusion/bruise (n=29) and muscle contusion (n=23). The distributions of injury locations and injury types per sport are presented in online supplemental appendices 2 and 3, respectively.

Mechanism, onset and circumstance of injuries

In terms of injury mechanisms (acute or repetitive) and mode of onset (sudden or gradual presentation), 65% (n=188) of the injuries were reported as having an acute mechanism with sudden onset, 14% (n=40) a repetitive mechanism with gradual onset, and 12% (n=37) a repetitive mechanism but with sudden onset (information missing for 24 injuries; further information on injury mechanisms in each sport is available in online supplemental appendix 4).

Forty-six per cent of the injuries (n=132) were sustained in competition, 40% (n=116) during training and 4% (n=13) during warm up or cool down (information missing for 28 injuries; details for each sport are presented in online supplemental appendix 1). For time loss injuries (n=100), 58% occurred in competition and 35% in training (3% in warm up/cool-down; information missing for 4%).

Illnesses overall, by sex and sport

Among the 2848 athletes, a total of 109 illnesses were reported, resulting in 3.8 illnesses (95% CI 3.1 to 4.5) per 100 athletes. This corresponds to 2.3 illnesses per 1000 athlete-days. On average, 4% (n=105) of the athletes incurred an illness, as four athletes incurred two illnesses each. When controlling for sport, age and NOC size, women (4.6 illnesses (95% CI 3.4 to 5.8) per 100 athletes) were at significantly greater risk of experiencing an illness than men (2.9 (95% CI 2.1 to 3.8), adjusted RR 1.58 (95% CI 1.05 to 2.38), information on sex missing for four illnesses, online supplemental appendix 1). Thirty-five per cent (n=38) of the illnesses led to at least 1 day of time loss.

Figure 2 shows the illness incidence proportion in each sport (additional details are available in online supplemental appendix 1). Ski aerobics had the highest illness incidence (10.2 illnesses (95% CI 1.3 to 19.1) per 100 athletes), followed by skeleton (8.0 (95% CI 0.2 to 15.8)), cross-country skiing (7.5 (95% CI 4.3 to 10.6)) and Nordic combined (6.9 (95% CI 0.1 to 13.7)).

Organ systems, aetiology of illness and COVID-19

The most affected organ systems/regions were the respiratory (n=52, 48%), gastrointestinal (n=14, 13%), dermatological (n=9, 8%) and ophthalmological (n=6, 9%) systems.

Of the 52 respiratory illnesses, 41 were caused by infection (28% of all illnesses, 1.4% of the athletes incurred a respiratory infection), of which 32, in turn, were SARS-CoV-2 infections (29% of all illnesses, 1.1% of the athletes). In addition to the cases occurring during the study period (4 February 2022–20 February 2022), 66 confirmed cases occurred before the Games

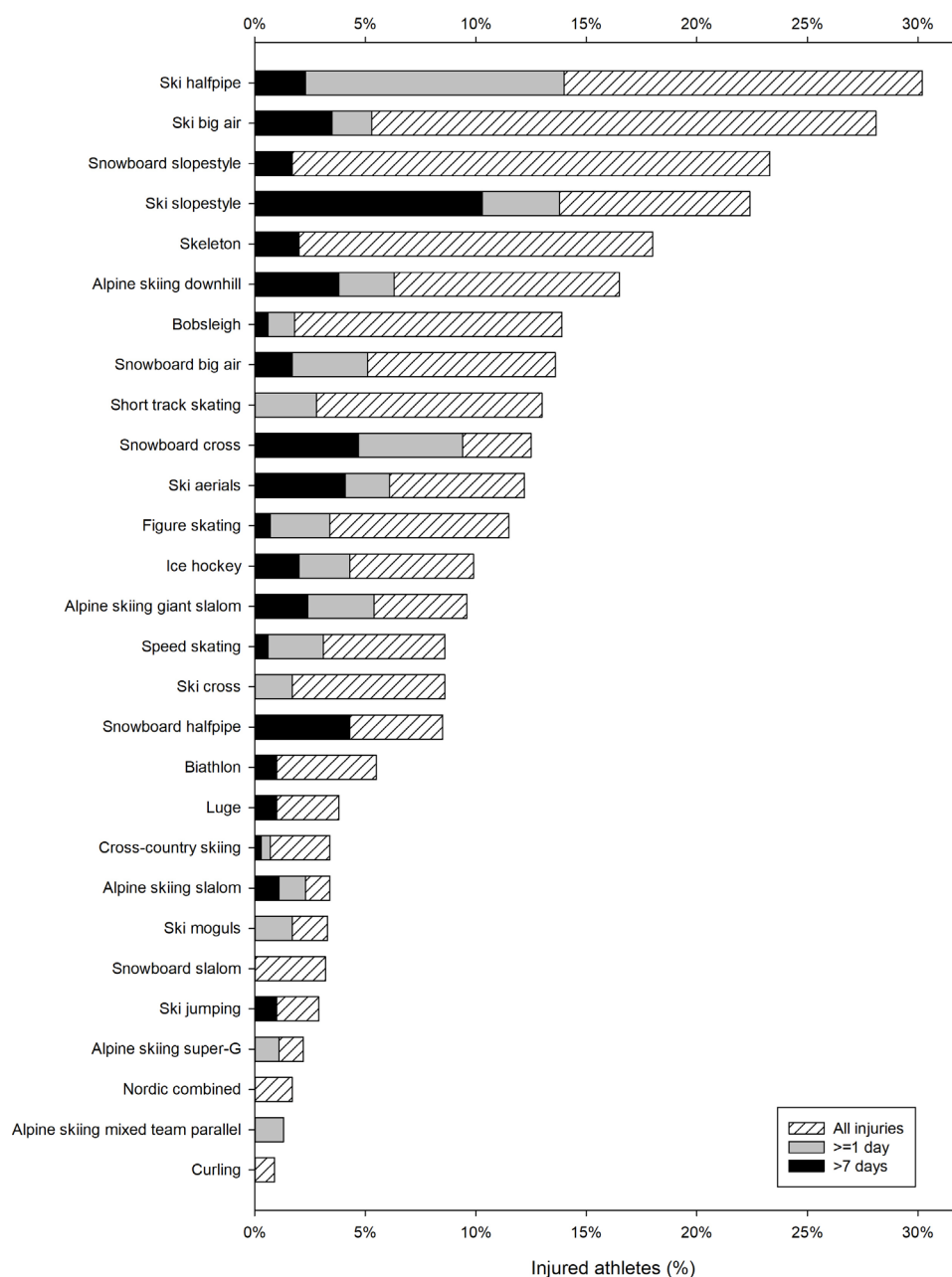


Figure 1 Proportions of athletes (%) in each sport with injury, injury with estimated time loss ≥ 1 day and injury with estimated time loss > 7 days.

started (ie, from arrival at the airport until the Opening Ceremony of the Games), giving a total of 98 cases of COVID-19 in athletes (3.4% of the athletes).

The distribution of affected systems and aetiology of illness per sport are presented in online supplemental appendices 5 and 6, respectively.

DISCUSSION

Injuries in the Olympic sports

The aim of the present paper was to describe the athlete injuries and illnesses which occurred during the Beijing 2022 Olympic Games. The injury incidence in the Beijing Olympics (10% of all athletes were injured) was comparable to those in the Winter Games of Vancouver 2010 (11%),⁸ Sochi 2014 (12%)⁹ and PyeongChang 2018 (12%).¹⁰

We identified ski halfpipe (30% of the athletes injured), ski big air (28%), snowboard slopestyle (23%) and ski slopestyle (22%)

as the disciplines with the highest injury incidences. Similar results were found in past Olympic^{8–10} and Youth Olympic Games,^{11–13} as well as by research from the Fédération Internationale de Ski (FIS) World Cup, in which both ski and snowboard slopestyle, big air, cross and halfpipe were found to have high injury rates.^{14–18}

Compared with the most recent Winter Games of PyeongChang 2018,¹⁰ the injury incidences in Beijing were lower in alpine skiing (6% vs 18% of the athletes injured), curling (1% vs 8%), ski cross (9% vs 25%) and ice hockey (10% vs 17%). A change in injury incidence can result from a multitude of factors, including but not limited to changes in environmental and weather conditions, venue or track design, competition rules, equipment, awareness and adherence to injury prevention training, injury and illness recording methods, and in the adherence of the medical staff recording the data.^{19–20} While injury risk factor and mechanism studies are needed to determine the

Box 1 Information on the 47 injuries with estimated absence >7 days

- ⇒ Twenty joint sprains/ligament tears (seven in ice hockey, five in ski slopestyle, two in ski big air, one each in alpine skiing downhill, alpine skiing giant slalom, alpine skiing slalom, snowboard cross, snowboard halfpipe and cross-country skiing).
- ⇒ Eleven acute bone fractures (two each in ice hockey and alpine skiing giant slalom, one each in alpine skiing downhill, biathlon, luge, snowboard cross, snowboard halfpipe, snowboard big air and snowboard slopestyle).
- ⇒ Four muscle strains/ruptures/tears (one each in alpine skiing slalom, bobsleigh, ski slopestyle and skeleton).
- ⇒ Three concussions/brain injuries (one each in ice hockey, ski halfpipe and ski jumping).
- ⇒ Two cartilage injuries (one each in alpine skiing downhill and speed skating).
- ⇒ Two bone contusions (one each in ice hockey and snowboard cross).
- ⇒ One tendon rupture in ski aerials.
- ⇒ One chronic instability in figure skating.
- ⇒ One muscle contusion in biathlon.

Details missing for two injuries

aetiology in each sport and discipline, longitudinal monitoring of injuries and illnesses is important to detect changes in injury incidences and characteristics over time.

COVID-19 in the Games

The Beijing Olympics followed much of the same recipe as the Tokyo Games, with playbooks detailing a number of COVID-19 mitigation policies and regulations in place for all participants.⁶ Key measures included a vaccination policy; testing, tracing and isolating; dedicated transport arrangements with no use of public transport; social distancing in villages and venues; good ventilation in all indoor areas; mask wearing; and a focus on personal hygiene (handwashing). With respect to testing, participants were required to provide proof of two negative PCR tests before departing for Beijing, another negative test on arrival, with subsequent daily screening tests throughout the Games.

However, at the time of the Games, there was a nationwide zero-COVID policy in China, which led to the implementation of a few significant additional strict countermeasures. A 'closed-loop' management system ensured almost complete separation between both international participants and local workforce inside the loop and the general population on the outside, minimising the likelihood of SARS-CoV-2 spreading in China. In addition, the vaccination policy was stricter because vaccinations were mandatory (they were recommended for Tokyo), prearrival testing was more comprehensive mandating PCR tests throughout (antigen testing was done at the airport in Tokyo), and the isolation times of anyone testing positive for SARS-CoV-2 were longer (14 days or until such time as consecutive daily tests were negative, whichever was the shorter period), as were the quarantine times of all close contacts.

Our results reflect the effectiveness of the COVID-19 countermeasures. Winter sport illness rates are usually higher than in summer sport, but the overall incidence of illness in Beijing was low (3.8 illnesses per 100 athletes); similar to Tokyo 2020 (3.9) but lower than PyeongChang 2018 (9.4),¹⁰ Rio 2016 (5.4),²¹ Sochi 2014 (8.9),⁹ London 2012 (7.2)²² and Vancouver 2010

(7.2).⁸ Only 1.4% of the athletes contracted a respiratory infection, which was lower than the two last Winter Games of PyeongChang 2018 (4.8%) and Sochi 2014 (4.2%), and similar to Vancouver 2010 (1.1%).

A small percentage of the participating athletes contracted COVID-19 (1.1% of the athletes, 3.4% of the athletes if including cases reported before the Opening Ceremony of the Games). While contracting COVID-19 was potentially devastating for some of the athletes in question as the required time in isolation prevented their possible lifetime Olympic participation, the relatively low number of COVID-19 positives was likely a testament to the concerted countermeasures by all stakeholders involved, allowing the successful running of the Games.

Limitations

In studies on sports injury, it is usually recommended to express incidences using a measure of time exposed to risk as the denominator.^{7 23} However, considering the inherent complexity and size of the Olympic Games, this was not feasible in this study. Instead, we expressed the injuries or illnesses as the number of new cases per 100 exposed athletes (incidence proportion). This approach erroneously assumes that the frequencies and lengths of exposure are identical in all sports, warranting caution when interpreting differences between sports in incidences of injury and illness. Furthermore, our data do not account for abbreviated lengths of exposure (due to injury, illness or late arrivals/early departures), but assume that all participating athletes were present and exposed in Beijing all days of the Games. Although it has been shown in the Paralympic Games that the variation between the actual number of exposed athletes and the total number of registered athletes is negligible,^{24 25} this limitation may result in an overestimation of exposure and an accompanying underestimation of the incidence of injury and illness.

In the current study, we included new or recurring injuries or illnesses receiving medical attention. By using this definition, gradual onset and less serious health problems may be overlooked, since they do not always require medical attention,^{7 26–28} although our results show that the majority of reported injuries and illnesses were estimated to not entail any time loss.

Nineteen per cent of the injuries and a mere 2% of the illnesses were captured by both the NOC and the Beijing 2022 medical personnel, underlining the importance of both recorder groups. As it is possible that some cases were captured neither by the NOCs nor the Beijing medical staff, our results likely underestimate the true incidence of injuries and illnesses.

Implications for research and practice

Guided by the available epidemiological data, the IOC has since 2018 funded a number of research projects with the long-term aim of reducing injury rates in ski and snowboard big air, slopestyle and cross. These studies seek to inform jump construction and course design—and hence athlete safety—through the collection and use of new data. Wolfspurger *et al* documented the air drag and lift during the in-run and flight phase of ski and snowboard slopestyle and big air, across various disciplines, postures and apparel.²⁹ They also combined, for the first time, kinematic athlete data and comprehensive snow-surface measurements to infer the coefficient of friction of freestyle skis and snowboards across a wide range of snow conditions, from very fast to very slow snow conditions.³⁰ Both the air drag and the ski/snowboard friction have direct influence on the athlete's take-off speed and therefore landing impact, and, hence, ultimately their injury risk. Furthermore, a current project is assessing the effect of the 'pop'

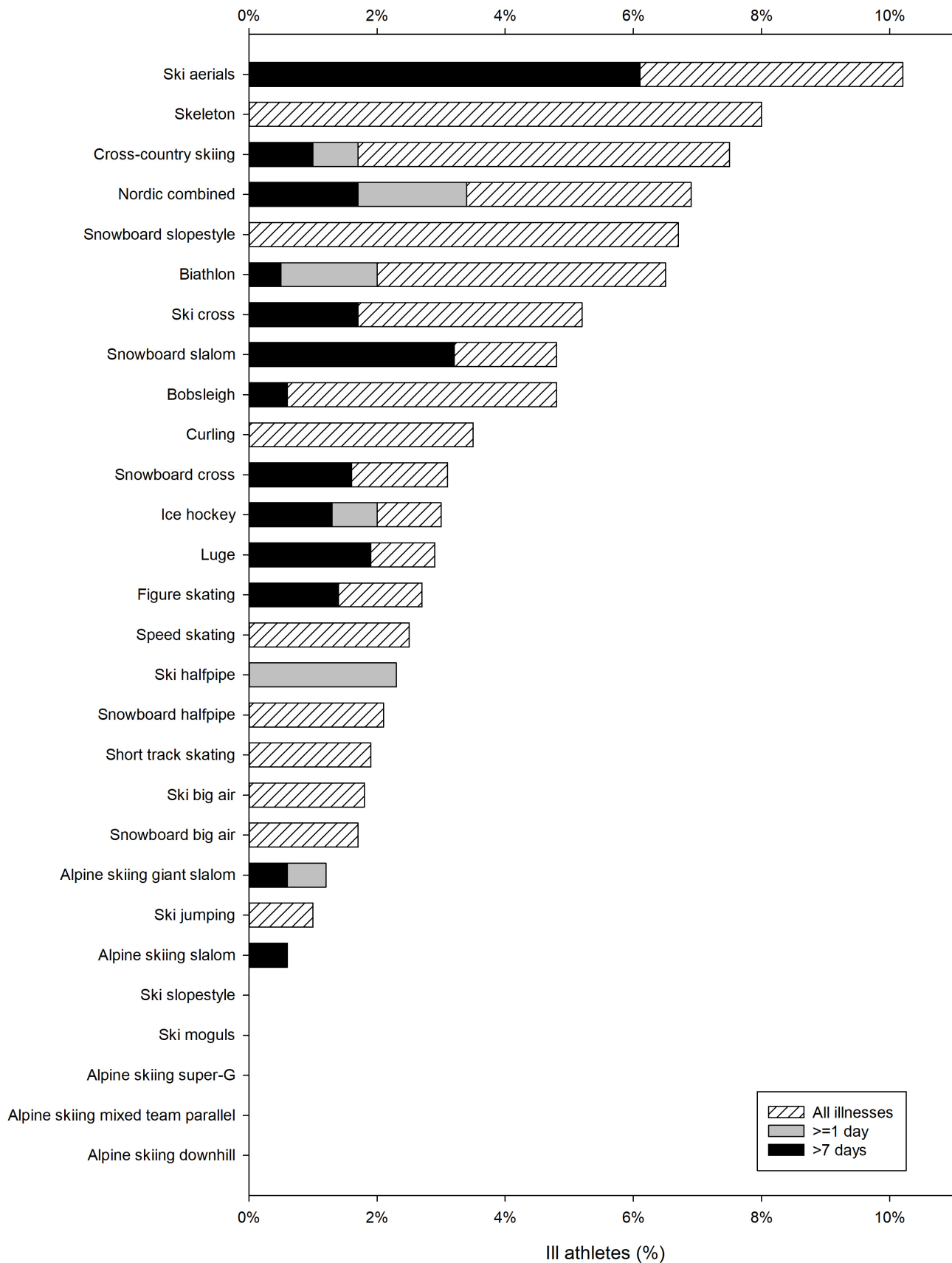


Figure 2 Proportions of athletes (%) in each sport with illness, illness with estimated time loss ≥ 1 day and illness with estimated time loss > 7 days.

to learn how elite skiers and snowboarders deploy muscular work in the take-off to increase or decrease the take-off angle on the kicker both to optimise their performance in the air and to hit the optimal landing zone on different types of jumps.³¹ Yet another study is assessing how rider behaviour (tricks) during the flight affects landing stability and therefore injury risk.³² Overall this research aims at facilitating valid simulations of both in-run kinematics and jump geometry and shape for a range of snow and wind conditions and across different types of athletes in a digital terrain and rider model prior to jump construction. By providing event organisers and park builders with such validated and free parameters and tools we can make the jumps safer for the athletes, mainly through reducing the likelihood of severe injuries in athletes landing with excessive impact outside the optimal landing area (jumping too far or too short).

CONCLUSION

In summary, 10% of the athletes were injured and 4% ill during the Beijing 2022 Winter Olympic Games. Freestyle skiing and snowboarding presented the highest injury rates. The illness incidence was similar to that of Tokyo 2020, but lower than in other past Winter and Summer Games. This may largely be attributed to the extensive countermeasures in place to mitigate COVID-19, effectively reducing transmission of not only COVID-19 but all respiratory infections. Our results can inform both the planning of future Olympic Games and similar events, the provision of healthcare to athletes in such events, as well as further research on understanding why the most frequent injuries and illnesses occur, and, importantly, how to prevent them in the future.

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Acknowledgements The authors would like to acknowledge the contribution and support of the Beijing 2022 staff throughout the different stages of this study. The authors also sincerely thank the NOC medical staff contributing to the data collection: Belen Moreschi (ARG), Ryan Leong (ASA), Donald Kuah (AUS), Bernhard Unterkofler (AUT), Joachim Westermeier (AUT), Stefan Neuhüttler (AUT), Eva Wartelsteiner (AUT), Johan Bellemans (BEL), Said Fazlagic (BIH), Iryna Maliovanaya (BLR), Felipe Hardt (BRA), Ronaldo de Carvalho Aguiar (BRA), Stefan Strugarov (BUL), Chris Beavington (CAN), Francis Fontaine (CAN), Gabrielle Ostiguy (CAN), Jeff Purkis (CAN), Laura Cruz (CAN), Lee Schofield (CAN), Michaela Kopka (CAN), Tina Atkinson (CAN), José Angel Rubio (CHI), Ji Ling (CHN), Helder Navarro (COL), Igor Boric (CRO), Jakub Hermanek (CZE), Anne Mette Stavsholm (DEN), Michael Seium (ERI), Jose Luis Martin Alguacil (ESP), Mihkel Mardna (EST), Katja Mjøsund (FIN), Maarit Valtonen (FIN), Matti Lehtovirta (FIN), Philippe le Van (FRA), Ajayi Abosede (GBR), Derich Mackeod (GBR), Holly RustMarch (GBR), Sian Knott (GBR), Bernd Wolfarth (GER), Ayishatu Farida Idriss (GHA), Jean Pierre Roy (HAI), Julian Chang (HKG), Szabolcs Toth (HUN), Harjinder Singh (IND), Abbas Nazarian Madavani (IRI), Ciara Elizabeth McCallion (IRL), Örnólfur Valdimarsson (ISL), Yaniv Ashkenazi (ISR), Ansen Sligar (ISV), Flavia Santoboni (ITA), Maria Rosaria Squeo (ITA), Wayne Palmer (JAM), Atsushi Teramoto (JPN), Azamat Nurmatov (KAZ), Olzhas Boltayev (KAZ),

Cholpon Zhumagazieva (KGZ), JungJoong Yoon (KOR), Sejun Kim (KOR), Liga Cirule (LAT), Mantvydas Šilkūnas (LTU), Geoffrey Osch (LUX), Majd Chekroun (MAR), Siew See Tan (MAS), Shadav Bolbarmaa (MGL), Marina Kosic (MNE), Rajko Kosic (MNE), Maarten Moen (NED), Oluwakemi Obidahunsi (NGR), Guri Ranum Ekås (NOR), Mona Kjeldsberg (NOR), Trond Floberghagen (NOR), Ginny Rutledge (NZL), Hamish Dickie (NZL), Nat Anglem (NZL), Saqib Nawaz (PAK), Hubert Krysztofiak (POL), Tiago Rosa (POR), Maxim Velichko (ROC), Anca Diana Torje (ROU), Dan Tanase (ROU), Brin Stabuc (SLO), Matjaz Turel (SLO), Gian Luca Gatti (SMR), Mikio Fukuda (SRB), German E. Clénin (SUI), Hanspeter Betschart (SUI), Lukas Weisskopf (SUI), Martin Narozny (SUI), Patrik Noack (SUI), Stefan Fröhlich (SUI), Stephan Rickli (SUI), Walter Frey (SUI), Fano Roman (SVK), Roman Fano (SVK), Jakob Swanberg (SWE), Varin Tansuphasiri (THA), Bogdan Bratkov (UKR), Allyson Howe (USA), Amber Donaldson (USA), Andrew Cooper (USA), Andrew Ernst (USA), Brett Toresdahl (USA), Chris Lefever (USA), David Weinstein (USA), Heather Cichanowski (USA), Jaron Santelli (USA), Jenna Street (USA), Jennifer Watters (USA), Jonathan Finnoff (USA), Kate Monan (USA), Kristin Abbott (USA), Marci Goolsby (USA), Mark Hutchinson (USA), Margot Putukian (USA), Michael J. Stuart (USA), Michael Noyes (USA), Peter Toohey (USA), Tracey Viola (USA), Nozim Atakulov (UZB).

Contributors TS, DP, KS, ADL, NG, XH, YW, M-EG, BGT, RB and LE contributed to the study conception and design, and data collection. TS and DP analysed the data. TS drafted the paper. All authors provided revisions and contributed to results interpretation and the final manuscript. TS is the guarantor.

Competing interests TS works as scientific manager in the Medical & Scientific Department of the International Olympic Committee. Kathrin Steffen is coeditor of the British Journal of Sports Medicine—Injury Prevention and Health Protection. RB is director of the Medical and Scientific Department of the International Olympic Committee. LE is Head of Scientific Activities in the Medical and Scientific Department of the International Olympic Committee, and Editor of the British Journal of Sports Medicine and associate editor of Journal of Bone and Joint Surgery. BGT is an associate editor of the British Journal of Sports Medicine and was a member of the medical staff for the United States at Beijing 2022 Winter Olympic Games.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval The study was reviewed by the Medical Research Ethics Committee of the South-Eastern Norway Regional Health Authority (2011/388).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as online supplemental information.

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